THE UNIVERSITY OF ALBERTA

A STUDY OF WATERFOWL NESTING ON ARTIFICIAL ISLANDS IN SOUTHEASTERN ALBERTA

by

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ABSTRACT

Use by nesting waterfowl of artificial islands created in impoundments of water in southeastern Alberta was studied from 1976 to 1978. A total of 1205 nests of 12 species of ducks and 144 nests of Canada geese (Branta canadensis) were found on the islands searched . Density of nesting ducks in the different impoundments varied between 2.3 and 29.1 nests per ha of which between 43 and 59% successfully hatched at least 1 egg. Mammalian predation was the main cause of nest failure. Greatest densities were recorded in 1977 when drought conditions were most pronounced; water persisting in the artificial impoundments seemed to attract waterfowl to nest on the islands. Mallard (Anas platyrhynchos), gadwall (A. strepera) and lesser scaup (Aythya affinis) were selecting islands to a greater extent than the other species of waterfowl found in the area. Of the 203 islands studied, 107 were used by Canada geese; they initiated an average of 1.35 nests per island and had a success rate of 70%.

By comparing production with various attributes of the islands, multivariate analyses showed that smaller islands located farther from shore and with a greater vegetative cover were the most productive. Recommendations for improving construction and placement of artificial islands are outlined. Moreover, the presence of nesting Canada geese on islands appeared to increase the density of nesting ducks and their success rate. The latter reflected an ability of geese to keep predators away from their nests and

coincidentally from those of ducks that nested in the vicinity.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Drainage of natural waterbodies and other agricultural practices have reduced the habitat suitable for nesting waterfowl on the North American prairies (Pospahala *et al* 1974, Merriam 1978). Creation of artificial islands for nesting waterfowl is one technique that has been proposed to protect and augment waterfowl production (Hammond and Mann 1956, Keith 1961, Mihelsons 1968, Sherwood 1968 and others). Greater production on insular habitats, relative to the mainland, generally reflects higher densities of nesting birds subjected to reduced pressure from mammalian predators (Hammond and Mann 1956, Hildén 1965, Mihelsons 1968, Vermeer 1970, Ewaschuk and Boag 1972).

For 40 years, Ducks Unlimited (Canada) has been constructing artificial earthen islands in impoundments of water as part of their habitat development and improvement programmes. However, little was known about the effectiveness of this programme in terms of either use or success of waterfowl nesting on them. The main objective of this study was to determine what physical characteristics of the islands influenced density and success of ducks and Canada geese nesting on them. Habitat selection by birds is influenced by stimuli from the physical environment and by interactions between birds of the same or different species (Hildén 1965). In this study, greater emphasis was given to the effect of the physical characteristics of the islands because it is possible to manipulate these factors. However,

the effect of nest density on nesting success of ducks and the social limitation of density in nesting geese were also investigated.

Another aspect of the study was to test the hypothesis of Long (1970) who suggested that nesting ducks were socially attracted to the vicinity of nesting Canada geese.

Finally, annual variation in weather conditions enabled me to study the effect of drought conditions on waterfowl use of artificial impoundments on the prairies.

Results are presented in the form of 3 individual papers which are integrated in a concluding discussion.

PAPER 1. USE OF ARTIFICIAL ISLANDS BY NESTING WATERFOWL

Abstract

From 1976 to 1978, the use by nesting waterfowl of artificial islands created in water impoundments was investigated in southeastern Alberta. A total of 1205 nests of 12 species of ducks and 144 nests of Canada geese (*Branta canadensis*) were found on the 203 islands searched over 3 years. Mallards (*Anas platyrhynchos*), gadwalls (*A. strepera*), and lesser scaup (*Aythya affinis*) selected islands as nesting sites more than the other species of ducks found in the area. Density of ducks in the different impoundments ranged from 2.3 to 29.1 nests per ha with a success rate that varied between 43 and 59%. Canada geese nested on 53% of the islands with a mean of 1.35 nests per island; their nesting success averaged 70%. Multivariate analyses of the islands' attributes and productivity showed that smaller islands, farther from shore and with a greater vegetative cover were the most productive. Means of improving construction, positioning and vegetating of islands are suggested.

Introduction

In recent years, construction of artificial islands as a management technique to overcome loss of nesting habitat (Merriam 1978) has been proposed by Hammond and Mann (1956), Keith (1961), Mihelsons et al (1967), Sherwood (1968), and many others. Greater production can be achieved on islands because waterfowl nest at higher densities and suffer less mammalian predation than on the mainland (Hammond and Mann 1956, Hildén 1965, Vermeer 1970a, Ewaschuk and Boag 1972).

Some studies have provided information on the characteristics of islands that make them most attractive to nesting waterfowl (Hammond and Mann 1956, Keith 1961, Sherwood 1968, Long 1970, and others). Recently Kaminski and Prince (1977) used multivariate analyses to distinguish quantitatively the factors that influenced selection of islands by nesting Canada geese.

The aim of this study was to use the Kaminski-Prince approach in determining which factors were important in limiting the number and nesting success of ducks and Canada geese using artificial islands in southeastern Alberta. Hildén (1965) stated that habitat selection by birds is influenced by the physical characteristics of the environment and by the presence of other birds of the same or different species. In this paper, I investigated the importance of the physical characteristics of the islands. Additionally, I measured the effect of nest density on the nesting success of ducks and geese and the effect of

interactions among geese in selecting their nest sites. Elsewhere (Giroux 1979a), I describe an interspecific association between ducks and Canada geese.

Study Area

The islands studied were located in 7 impoundments created by Ducks Unlimited (Canada) near the town of Brooks (50.6° N, 111.9° W) in southeastern Alberta (Table 1). This is in a region of mixed-prairie 50 km southeast of the area described in detail by Keith (1961).

Impoundments A and B are 2 adjacent irrigation reservoirs. Artificial islands, located at various points along their shores, were created by isolating tips of peninsulas through excavation of ditches on the landward side. They presently range in size from 0.13 to 6.6 ha. Two types were recognized: larger islands with 1 or more heaps of earth but with more than 40% of their area covered with native mixed-prairie vegetation (Coupland 1950), and smaller islands with isolated piles of earth but less than 40% of their area covered by native grassland vegetation. Pioneer vegetation had invaded these piles of exposed earth which now support stands of forbs ("forbs" type, Table 2) such as Russian thistle (*Salsola kali*), tansy mustard (*Descurainia sophia*), narrow-leaved goosefoot (*Chenopodium leptophyllum*), tumbling mustard (*Sisymbrium altissimum*), burning bush (*Kochia scoparia*), and grasses ("grass" type, Table 2) such as foxtail barley (*Hordeum jubatum*), western wheat grass (*Agropyron smithii*), and crested wheat grass (*A. cristatum*), the last species having been seeded in 1974. Water levels in each reservoir are regulated; from early May to the end of July they are drawn down in response to irrigation

requirements, being refilled in fall and early spring with water from the Bow River.

The 5 other impoundments (C, D, E, F, and G) are located in shallow basins about 15 km southeast of reservoir B. In each of these basins a series of artificial islands was created with earth scrapers before flooding. Most were built by piling up the earth that was scooped out of a 10-m wide moat down to a depth of about 75 cm. Some were made by piling up the earth from an adjacent borrow-pit. The resulting islands are rectangular in shape, 1 to 2 m high, and cover from 0.09 to 0.47 ha. Between the moat and the pile of earth, a berm of 3 to 5 m was left intact. This has become covered by spike rush (*Eleocharis palustris*) and water smartweed (*Polygonum coccineum*) ("emergent" type, Table 2), and is subjected to flooding. The piles of earth have been colonized by such species as tansy mustard, burning bush, lamb's-quarters (*Chenopodium album*), bull thistle (*Cirsium vulgare*), gumweed (*Grindelia squarrosa*), foxtail barley, and western wheat grass. Islands in basin F and G were seeded with a mixture of crested wheat grass (40%), Russian rye (*Elymus junceus*) (40%), and sweet clover (*Melilotus* sp) (20%) in the spring of 1977. In fall and early spring, these shallow basins are flooded with water from reservoir B through a series of canals. Water levels decrease during the summer through evapo-transpiration at a rate of approximatively 15 cm per month. In some years, water disappears over most of each basin, remaining only in

the moats around the islands by the month of July.

Surrounding uplands are grazed by cattle which often concentrate near the flooded basins where they can find both water and green vegetation. They grazed intensively between the islands of the low-lying basins and on some islands where insufficient water remained to deter them crossing the moat.

Methods

Relative numbers of each waterfowl species present in the different basins were estimated by counting the indicated breeding pairs (Dzubin 1969). In 1976, a single count was done in each area between 12 and 21 May by 1 observer walking the shoreline of each impoundment. The following year, 3 to 4 counts were conducted between 15 April and 1 June by 1 or 2 observers walking, canoeing or from a vehicle.

Number and species of waterfowl nesting on the islands were recorded from 1976 through 1978. Nesting habitat (37 ha) on 75 islands was searched annually during the 1st 2 years and a sample of 53 of these islands (13 ha) was searched during the 3rd summer. In 1976 and 1978, 2 systematic searches were done by 1 or 2 observers walking a series of parallel transects; a 3rd visit to the islands in 1976 checked the fates of late nests. In 1977, 4 systematic searches were done by 2 observers walking parallel transects perpendicular to each other. On reservoir A, the 4th visit checked the fates of late nests. Transects were 2-3 m apart depending on vegetation density. A short stake was used to beat dense vegetation.

A nest was recorded if it contained 1 or more eggs. If whole eggs were absent (owing to predation), presence of fresh down, nest material, and sometimes eggshell fragments were taken as evidence that a nest had been initiated in that season and so was recorded. Nests were classified as

"active" if hens were laying or incubating and "inactive" if clutches had been hatched, deserted or destroyed. The species of waterfowl occupying a nest was identified either by seeing the female as it flushed or by characteristics of the nest, eggs, down, and contour feathers. Stage of incubation of each clutch was determined by floatation of eggs (Westerskov 1950). Locations of nests were plotted on field-maps; markers were not used because they could have attracted avian predators (Picozzi 1975). A nest was considered successful if at least 1 egg of the clutch hatched.

The physical characteristics of islands varied within and among basins. In 1977, a series of independent variables were measured on each island in an attempt to determine which of these factors or set of factors explained most of the variation of the dependent variables (density and nesting success of ducks and geese). Area and length of island shoreline were calculated with a planimeter and a map measurer either from aerial photos or from maps drawn by the compass transverse and intersection method (Mosby 1971). Vegetation of the islands was classified into 7 types (Table 2); the proportion of each island covered by the different types in July was calculated with a planimeter. By comparing availability of each type and its use by nesting waterfowl, I determined that "forbs" and "grass-forbs" were preferred by nesting waterfowl (Table 2). The proportion of each island covered by these 2 types was then included in

the set of independent variables. Water depth and distance between each island and the mainland shore were measured in early May and early July. The age of each island was based on the number cf summers since its construction.

Variations in density and nesting success of ducks were analysed by stepwise regression (Draper and Smith 1966). The criterion for retaining or deleting a variable was based on the 5% level of probability and aptness of the model was examined through the study of the residuals (Neter and Wasserman 1974). The logarithmic transformation was used to linearize the regression function and to stabilize the variance of the error terms while the angular transformation was applied to data represented by percentages (Sokal and Rohlf 1969).

Because the number of Canada geese nesting on the islands was limited, a discriminant function analysis was used to compare islands used and unused by nesting geese, and islands with successful and unsuccessful goose nests. The independent variables were also selected by a stepwise procedure on the basis of their discriminant power; the selection criterion was the smallest Wilks' lambda (Nie et al 1975).

Other statistical analyses were performed according to Sokal and Rohlf (1969); the significant level of probability was established at 5%.

Results and Discussion

Species composition

During the study, 1205 nests of ducks (12 species) and 144 nests of Canada geese were found on the 203 islands searched. Among ducks, lesser scaup, mallards, gadwalls, pintails (*Anas acuta*), and blue-winged teal (*A. discors*) were the most common species to use the islands as nesting sites (Table 3). When the species composition of ducks nesting on islands in the 2 types of basins were compared, a significant difference emerged. Islands in the larger and deeper reservoirs (A and B) supported a greater proportion ($P<0.005$) of diving ducks, 34% of the nesting birds (Table 3). By contrast, divers made up only 18% of the nesting population in the low-lying basins (C, D, E, F, and G).

The extent to which the most common species in the area used islands as nesting sites was judged by comparing counts of breeding pairs with those of nesting birds (Table 4). Results indicate that mallards, gadwalls, and lesser scaup sought out islands as nesting sites whereas pintails, teal, northern shovelers (*A. clypeata*), and American wigeon (*A. americana*) avoided islands. These data are supported by the species composition of ducks nesting on the mainland. Of 46 nests found on the adjacent mainland, 46% were pintail, 20% teal, 13% lesser scaup, 9% northern shoveler, and 2% American wigeon; mallard and gadwall together accounted for only 10%. Other studies have also reported that mallards

(Drewien and Fredrickson 1970, Vermeer 1970b), gadwalls (Henry 1948, Hammond and Mann 1956, Duebbert 1966), and lesser scaup (Keith 1961, Long 1970) nest at high densities on islands.

These findings indicate that female mallard, gadwall and lesser scaup may be more tolerant (Duebbert 1966, Pulliainen and Niemelä 1975) or even socially attracted by conspecifics (Hammond and Mann 1956, Duebbert 1966) promoting higher densities among them. For the other species, it is not possible to decide whether they were avoiding the islands *per se* or whether they were intolerant of or subordinate to individuals already established on the islands.

Density of duck nests

I believe that all females on nests were flushed on each island, regardless of vegetative cover and observer attentiveness. Therefore, the group of nests located by flushing females is representative of the nesting population at the time of the census. A strong correlation (r=0.92, df=126, P<0.01) between the number of nests located by flushing a female and the number of "active" plus "inactive" nests found on the islands suggests that the latter sum represents the nesting population adequately and allows comparisons of nesting densities between islands.

The average density over the 3-year period varied from 2.3 nests per ha on the recently-created islands at F and G

to 29.1 nests per ha on the older islands at D (Table 5). Annual variation in density was recorded with the greatest number of nests being found during a period of drought in 1977. Water persisting in the artificial basins under investigation that year seemed to attract waterfowl to nest on the islands in them (Giroux 1979b). Density of nesting ducks observed in this study is somewhat lower than other densities reported on islands (Table 6). However, it appears that, when islands are present in high density (Long 1970, Vermeer 1970b, this study), they are used differentially. These data support the conclusion that islands, even artificial ones, are attractive to ducks. The number of nests per ha on mainland habitat is reported to vary between 0.0 and 4.3 (Oetting and Dixon 1975).

Density of nesting ducks was inversely correlated with size of island in the reservoirs and the low-lying basins (Table 7). A similar relationship has been reported by Mihelsons et al (1967) and Vermeer (1970b). The smallest island studied (0.09 ha) supported 10 duck nests in 1977 (111 nests per ha), the highest density recorded. However, the minimal size, beyond which interactions between birds may prevent establishment of more than 1 pair per island, has yet to be determined. Johnson et al (1978) reported high densities of mallards (Table 6) on very small islands (0.0025 ha), but I consider that it is not appropriate to present the number of nests per ha when only 1 nest can be initiated on such small islands.

On islands in reservoirs A and B, density of nesting ducks was positively correlated with distance of island from shore in May (Table 7). Islands located far from the mainland had greater densities (46.8 nests per ha) than islands of similar size located close to shore (33.7 nests per ha).

In the low-lying basins, the proportion of an island covered by preferred vegetation (Table 2) explained 70% of the variation in density of duck nests (Table 7). Older islands had a greater proportion of their area covered by this vegetation (r=0.75, df=33, P<0.01). Moreover, the proportion of the island covered by preferred vegetation was also correlated with depth of water around the islands at D (r=0.58, df=12, P<0.05) and at E (r=0.75, df=15, P<0.01). This suggests that presence of water around islands promotes growth of vegetation, a suggestion supported by the fact that density of vegetation was greater nearer the water (on the slopes) than on the tops of the islands.

Density of Canada goose nests

Of the 203 islands investigated in this study, Canada geese used 107 (53%) as nesting sites; they initiated a mean of 1.35 nests per island. Geese showed a distinct preference for the artificial islands since only 1 goose nest was found on the mainland adjacent to a basin. Between 1976 and 1978, a total of 53 islands were observed annually and the proportion used by Canada geese for nesting rose from 43 to

62 to 75%. This increased use was associated with a progressive colonization of the more recently-created islands which may reflect either immigration into the study area or an increase in the local breeding population. The average density of island-nesting geese, over the 3-year period, ranged between 0.2 and 7.1 nests per ha in the different basins. Densities greater than 25 nests per ha have been reported for Canada geese nesting on islands (Naylor 1953, Munro 1960, Ewaschuk and Boag 1972) but in all cases the number of islands per impoundment was much lower than in the basins investigated in this study.

Canada geese selected nesting islands that were characterized by deeper surrounding water and greater coverage of "forbs" and "grass-forbs" (Fig. 1). Islands surrounded by deeper water may represent safer nesting sites for geese. Greater density of vegetation may also be advantageous through reducing interactions among nesting geese. However, it seems to contradict the findings of Kaminski and Prince (1977) in southeastern Michigan. They found that islands selected by nesting geese had a lower density of vegetation and hence good visibility. However, the vegetaticn found on the islands investigated in this study was short allowing geese to observe the surrounding area when standing up near their nests whereas vegetation on the Michigan islands ranged from 1.5 to 2.4 m in height and would not have permitted geese such visual freedom. Moreover, presence of visual barriers which would decrease

interactions between pairs was probably less important in their study area since density of the breeding population was much lower than in mine (1.2 vs 9.6 pairs per 10 km^2).

Establishment of more than 1 goose nest per island was recorded in a few instances when visual barriers were provided by vegetative cover or by the physiognomy of the island itself. In March and April 1977, geese selecting nest sites were observed for 250 hours from an elevated blind located in the vicinity of the islands (0.09 to 0.3 ha) at D. A pair of geese usually defended an entire island. However, 2 nests were initiated on each of the 3 islands with the greatest proportion (89, 98, and 99%) of their surface covered with forbs and grass-forbs. On those islands, dry vegetation of the previous year completely concealed the geese when constructing their nests or laying. This reduced ($\underline{P}<0.005$) the number of interactions between pairs during the pre-incubation period. At the 3 islands with 2 goose nests, I recorded 8.5 interactions per pair per island whereas at the 9 islands with only 1 nest I recorded 16.6 interactions per pair per island. These observations support the suggestion that dense vegetation may lower visual stimuli and hence decrease interactions between pairs of Canada geese (Munro 1960, Ewaschuk and Boag 1972). These interactions are believed to influence establishment of territory and nest site selection of geese (Klopman 1958). Thus, a good cover of forbs over the entire islands may permit establishment of 2 goose nests per island, possibly

the maximum number before the effect of crowding would reduce nesting success (Naylor 1953, Munro 1960, Ewaschuk and Boag 1972).

Nesting success of ducks

The ultimate factor prompting anatids to select islands as nesting sites is the protection the islands provided against mammalian predators and thus the reproductive success of ducks using them (Hildén 1965). Keith (1961) and Townsend (1966) showed that ducks nesting on islands had greater hatching success than on the mainland. Long (1970), reviewing nesting success of ducks in several studies of island habitat, concluded that it was generally greater than 70%. However, Hammond and Mann (1956) noted that predation remains the primary cause of waterfowl losses on islands.

Clutches that have been destroyed by predators are believed to be more conspicuous to man than those that hatched (Kalmbach 1938). This would tend to bias upwards the number of preyed-upon nests in the sample. I found that "inactive" nests were proportionately more unsuccessful ($P<0.005$) than nests located by flushing females. Therefore, it seems more appropriate to omit "inactive" nests in calculating nesting success.

In 1976 and 1977, 59% of 220 duck nests found on islands of the low-lying basins were successful. On islands in the reservoirs A and B, nesting success was also lower than expected since only 43% of 367 nests hatched at least 1

egg. In all waterbodies, decreasing water levels through evapo-transpiration and irrigation draw-down reduced the security of islands against mammalian predators. Of 301 nesting failures, 3% were deserted, 57% were lost to mammalian predators (skunks, *Mephitis mephitis*; badgers, *Taxidea taxus*; and coyotes, *Canis latrans*), 1% to avian predators, and for 40% the cause of failure was unknown.

Nesting success of ducks was positively correlated with distance of island from mainland shore in early July (Table 7). Although it explained only 30% of the variation, this factor was the most important at both types of waterbodies. Depth of water surrounding an island did not contribute significantly to the variation in nesting success.

The effect of density of ducks on their nesting success was investigated either because interactions between birds might decrease their success or because high concentrations of ducks might be more vulnerable to predation. Such a relationship was not found. In fact there was a positive correlation between nesting success and density (r=0.54, df=47, P<0.01) which suggests that more females were selecting safer islands as nesting sites. Duebbert (1966) noted that hatching success of gadwalls was not reduced at nesting densities as high as 43 nests per ha. However, Long (1970) reported that nesting behavior was "abnormal" at densities of 130 nests per ha. Dropped eggs, nest desertion and nest parasitism were frequent when ducks nested in these

extreme concentrations on islands.

In this study, 12% of 743 nests located in 1977 contained eggs that appeared to have been laid by 2 or more females (inter- or intraspecific parasitism). The frequency of parasitized nests was positively correlated with the density of nests in the different basins ($r=0.95$, df=4, $P<0.01$). Joyner (1976) has shown that eggs in parasitized nests have lower hatching success than in unparasitized nests. Nesting success based on the clutch, not the individual eggs, did not show any negative effect of density in this study but perhaps information on egg success would have given a different result.

Nesting success of Canada geese

During the 3 years of the study, 101 nests (70%) of Canada geese hatched at least 1 egg, 25 (17%) were preyed-upon, and 18 (13%) were deserted. This level of nesting success is equivalent to 67% calculated for nearly 5000 nests reported in several studies on islands (Naylor 1953, Sherwood 1968, Vermeer 1970a, Hanson and Eberhardt 1971, Ewaschuk and Boag 1972). All desertions occured on islands in low-lying basins where density of nesting geese was greater and where social interactions between pairs may have been the cause (Ewaschuk and Boag 1972). This contention is supported by the fact that a greater success ($P<0.005$) was recorded for geese nesting singly on islands (80% of 60 nests) than for geese nesting on islands where

there was more than 1 nest (53% of 43 nests). During the incubation period, the situation observed during the pre-incubation was reversed. When geese are established on islands, the number of interactions involving pairs nesting singly on adjacent islands is probably lower than for pairs nesting in close vicinity on a same island. Ewaschuk and Boag (1972) recorded a smaller nearest-neighbor distance between unsuccessful nests than between successful nests. Nevertheless, the number of goslings produced per island was greater on islands with 2 than with 1 nest.

Distance between island and mainland in May and percentage of island surface covered with "forbs" and "grass-forbs" (Table 2) were most influential in separating islands with at least 1 successful goose nest from those without a successful nest. Islands with successful nests were located either farther from shore or had denser vegetation (Fig. 2). Importance of distance of islands from shore may reflect the same effect of discouraging mammalian predation as has been suggested for ducks in this study. Also, it has been suggested by Ewaschuk and Boag (1972) that increased vegetative cover may reduce the number of interactions between pairs of geese and consequently lower their rate of desertion. Moreover, there is perhaps a compensatory effect between the 2 variables since heavy vegetation may make geese less visible to predators when nesting on islands near shore.

Management Recommendations

Comparison of island characteristics and productivity showed that smaller islands located farther from shore and with a greater vegetative cover were the most productive. Keith (1961) observed that preferred islands were at least 15 m in diameter (0.02 ha) while Hammond and Mann (1956) suggested islands of 0.12 to 0.4 ha. From this study, I would recommend that islands encompass about 0.1 ha. Smaller islands may be even better but as yet the optimal size is not known.

Keith (1961) claimed that a moat 45 to 60 cm deep and about 10 m wide was adequate to deter skunks. Hammond and Mann (1956) suggested a depth of 30 to 45 cm with "several hundred feet of open water" while Sherwood (1968) recommended locating islands at more than 60 m with a minimal depth of 30 cm. However, coyotes (Hanson and Eberhardt 1971) and badgers (Duebbert 1967) have been observed to swim over 200 m without any apparent stress. I recorded a skunk swimming between islands over a distance of more than 200 m. Based on the relationship between nesting success of ducks and distance of island from mainland shore in July ($Y = 28.45 + 0.36X$), I would recommend a distance of at least 170 m between island and mainland shore. Since geese were using islands surrounded by a mean depth of 69 cm of water, I consider that a depth of about 75 cm should be adequate to make an island attractive, providing it is sufficiently far from shore.

Nesting waterfowl selected stands of broad-leaved annuals and perennials mixed with grasses. Establishment of vegetation on islands could be promoted by seeding a mixture of grasses and legumes (Duebbert and Lokemoen 1976). Type of soils and moisture conditions particular to each area will determine the species to seed. Most of the artificial seeding done on islands in the Brooks area was unsuccessful or very slow to become established, probably because of the dry conditions on the islands. Under such conditions, I suggest that watering the islands at the time of seeding will accelerate establishment of nesting cover. Flooding of the basin will raise the water table under the islands but can be detrimental to islands through erosive action of waves against unprotected shores.

In the reservoirs, the large cut-off peninsulas with more than 40% native grassland vegetation were less attractive to waterfowl than the smaller islands with greater coverage of forbs and grass-forbs. This suggests that the former should not be constructed when costs of the 2 types are similar.

Islands created in the shallow basins by piling up earth from an adjacent borrow-pit were surrounded by flooded emergent vegetation except on the borrowed side where there was open water. These islands were used less by ducks as nesting sites than islands with a complete moat (8.2 vs 15.2 nests per ha). Thus islands should be constructed with a complete moat so that there is open water all around the

island.

Rectangular islands appear the most appropriate because such islands have greater perimeter per given area than circular, elliptical or square islands. The greater the ratio of water-land edge to land mass the more attractive the insular habitat (Hammond and Mann 1956). Moreover, rectangular islands require limited surveying and are easier to build, especially with a scraper. Heavy equipment travelling and unloading material on the central pile of earth results in a more compacted and erosion-resistant island.

Erosion is the most important factor influencing longevity and therefore productivity of an island. For islands covering from 0.1 to 0.4 ha, Hammond and Mann (1956) reported a reduction in size of 65 to 75% in 14 years. In this study, the effect of erosion was more marked in reservoirs than in low-lying basins. Actual reduction in size of eroded islands was not measured but was usually limited since islands were all recently-constructed and also because declining water levels in the shallow impoundments reduced wave action.

To minimize erosion, I suggest that islands be oriented parallel to the prevailing winds. Hammond and Mann (1956) suggested that emergent vegetation around the island can be used as natural breakwaters. However, Mihelsons _et al_ (1967) observed that islands surrounded by a dense belt of tall emergent vegetation offered no access to open water and were

avoided by waterfowl. The importance of free access to open water from the island was suggested at D where I noted that geese approached or left islands more often by swimming than by flying (430 vs 105 observations). I suggest that dense emergent vegetation should be left only on the windward side of an island. In large waterbodies where wave action is significant, islands should be located along the lee shore. Rip-rapping the windward shores of islands subjected to erosion is a costly possibility and its effect on waterfowl is unknown.

Hammond and Mann (1956) suggested that close spacing of islands protects them from wind and wave action. However, clustering of islands can increase their vulnerability to predators (Sherwood 1968), a phenomenon also recorded in this study. At D, greater nesting success of ducks ($\underline{P}<0.005$) was recorded on islands that were separated by more than 100 m (89% of 28 nests) than on islands at less than 100 m (54% of 41 nests). Since these islands were at the same distance from shore, their close spacing may have decreased their productivity. More experiments should be conducted to test this apparent relationship. Sherwood (1968) suggested that small islands constructed for nesting Canada geese should be more than 45 m apart; results of this study indicate that islands of 0.1 to 0.2 ha should be no closer than 100 m.

Increase in the breeding population of Canada geese in the study area and progressive colonization of the more

recently-created islands by geese suggests that availability of nesting sites may be a limiting factor on the prairies of southeastern Alberta. It also shows the potential of constructing islands in different impoundments located in the same general area to increase local populations of geese.

It is appropriate to subject the construction of artificial islands to a cost-benefit analysis. Hammond and Mann (1956) estimated a rate of \$0.16 per m^3 of earth moved for the construction of islands in 1955. In 1968, islands built by Ducks Unlimited (Canada) with a scraper at impoundment D cost about \$300 each or \$0.29 per m^3. By 1979, this rate had risen to between \$1.00 to \$1.70 per m^3 depending upon quality of material and working conditions. At D, an average of 4.5 goslings and 25.5 ducklings per island are produced annually, based on 4.5 goslings and 7.5 ducklings per successful nest (Vermeer 1970a,b). Considering an actual expenditure of \$1400 per island or \$1.35 per m^3, the cost per bird hatched over a 20-year period would be \$2.33 (1979 Canadian funds). Since the life expectancy of these islands is more than 20 years, each additional year of production would reduce the cost per bird produced.

Compared to other techniques such as idle cropland (Duebbert and Lokemoen 1971) or artificial nesting structures (Rienecker 1971, Doty _et al_ 1975), islands are more expensive. However, they require less maintenance, more ducklings and goslings are hatched per unit area on them,

and they are used by a greater diversity of species.

Complete evaluation of the utility of islands in waterfowl production will be completed only when information on the survival of broods to fledging is known. It is also important to know whether ducks using islands are birds drawn from other parts of the marsh or represent an actual increase in the breeding population. If birds nesting on islands are only drawn from other parts of the marsh, they may nevertheless enjoy greater nesting success there than on the mainland, thus producing more ducklings. Moreover, any "vacancies" created by the movement of birds to islands, may be filled by other breeding pairs.

More investigation should be conducted to determine if increasing density of islands augments the nesting population of an impoundment or contributes only to disperse ducks present among more islands.

Finally, the use of artificial islands by waterfowl should be studied in other ecological zones such as the parkland or the boreal forest to determine if the technique is also effective and whether the same factors influence density and success of waterfowl there as on the prairies.

Acknowledgements

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Table 1. Characteristics of 7 impoundments constructed by Ducks Unlimited (Canada) and located near Brooks, Alberta, 1977.

Impoundment	Basin			Artificial islands			
	Area flooded (km^2)	Peri-meter (km)	Max. depth (m)	Number	Date of construc-tion	Total area (ha)	Total peri. (km)
Tilley A (A)[a]	4.6	33.9	1.8	8	1971-72	19.1	5.4
Tilley B (B)	13.0	30.9	5.3	17	1973	11.7	6.1
Tilley H (H)	1.1	7.6	0.5	8	1973	2.1	2.0
Tilley O (O)	0.7	4.2	0.3	8	1975	1.3	1.3
Tilley P (P)	0.2	2.3	0.8	3	1975	0.6	0.5
Kininvie Flats (D)	2.3	17.5	0.9	14	1968	2.5	2.5
Kininvie South (E)	1.4	9.8	0.8	17	1974	4.7	3.7

[a] Impoundments are referred to in the text by letters in parentheses.

Table 2. Percentage of duck nests observed and expected[a] in 7 types[b] of vegetative cover on artificial islands near Brooks, Alberta, 1976-77.

	Percentage of nests in						
	forbs	grass-forbs	grass	shore	pioneer	emergent	grassland
Observed	44.7(441)[c]	30.2(298)	3.5(34)	8.4(83)	5.8(57)	1.1(11)	6.3(62)
Expected	17.3(171)	18.9(186)	2.5(25)	11.9(117)	7.9(78)	4.8(47)	36.7(362)
$\underline{P}$[d]	<0.005	<0.005	>0.05	<0.005	<0.025	<0.005	<0.005

[a] The number of expected nests is based on the availability of each vegetation type (% of total insular surface [69ha] dominated by the different types x total number of nests observed [986]).

[b] forbs: stands of broad-leaved annuals and perennials.
grass: stands of grasses.
grass-forbs: heterogeneous stands of the 2 previous types.
shore: colonizing vegetation on shores.
pioneer: sparse vegetation (grasses and forbs) colonizing the piled earth.
emergent: vegetation between moat and piled earth.
grassland: mixed-grass prairie vegetation (Coupland 1950).

[c] Figures in parentheses represent the number of nests.

[d] Based on chi-square goodness-of-fit test.

Table 3. Species composition of ducks nesting on islands located in reservoirs and low-lying basins near Brooks, Alberta, 1976-78.

Species	Number of nests	
	Reservoirs	Low-lying basins
Mallard	118 (17)[a]	94 (21)
Gadwall	139 (20)	69 (15)
Pintail	60 (9)	107 (24)
Teal[b]	69 (10)	62 (14)
Northern shoveler	35 (5)	25 (5)
American wigeon	39 (5)	15 (3)
Total dabbler	460 (66)	372 (82)
Lesser scaup	210 (30)	57 (13)
Redhead	17 (2)	18 (4)
White-winged scoter	12 (2)	1 (0)
Ruddy duck	-	4 (1)
Total diver	239 (34)	80 (18)
Total ducks	699 (100)	452 (100)

[a] Figures in parentheses are percentages.

[b] All 3 species of teal (*Anas discors*, *A. crecca*, *A. cyanoptera*) were grouped together.

Table 4. Relative use of islands by nesting ducks near Brooks, Alberta, 1976-77.

Species	Reservoirs		Low-lying basins		Mean
	1976	1977	1976	1977	
Mallard	1.8[a]	1.3	4.2	2.0	2.3
Gadwall	1.7	1.4	1.7	2.1	1.7
Lesser scaup	1.7	1.8	1.4	1.1	1.5
Pintail	0.4	0.7	0.7	1.0	0.7
Teal[b]	0.5	0.6	0.9	0.8	0.7
Northern shoveler	0.7	0.8	0.5	0.4	0.6
American wigeon	0.8	0.3	0.3	0.3	0.4

[a] Percentage of all ducks nesting on islands in given type of waterbody divided by percentage of all breeding pairs counted at that given waterbody.

[b] All 3 species of teal were grouped together.

Table 5. Densities of nesting ducks on artificial islands near Brooks, Alberta, 1976-78.

Impoundment	No. of nests per ha			
	1976	1977	1978	Total
A	3.9	14.9	a	9.4
B	7.3	26.1	23.6	17.3
C	5.0	31.0	11.7	14.2
D	23.6	36.0	27.1	29.1
E	15.4	11.3	13.2	14.4
F and G	0.5	2.1	4.3	2.3
Total	7.1	19.4	16.4	13.8

[a] Islands in impoundment A were not searched in 1978.

Table 6. Reported densities of nesting ducks on islands.

Number of islands[a]	Total area (ha)	Density (No.nests/ha)	Dominant species	Location	Authority
1	0.32	494.2	gadwall	N. Dakota	Henry 1948
2	5.7	35.1	gadwall	N. Dakota	Duebbert 1966
1	42.5	16.1	mallard, tufted duck	Scotland	Boyd and Campbell 1967
5	20.0	16.3	?	USSR	Mihelsons _et al_ 1967
1	7.7	21.4	mallard	S. Dakota	Drewien and Fredrickson 1970
22	32.7	12.6	lesser scaup, mallard	Alta.	Long 1970
19	59.5	3.8	mallard	Alta.	Vermeer 1970b
8	15.2	19.4	lesser scaup, gadwall	Alta.	Dwernychuk and Boag 1973
10[b]	0.4	62.0	gadwall	Sask.	Hines 1975
56[b]	0.14	135.7	mallard	N. Dakota	Johnson _et al_ 1978
203[b]	87.6	13.8	lesser scaup, mallard, gadwall	Alta.	This study

[a] The same island can be observed for more than 1 year and therefore can be counted more than once.
[b] Man-made islands.

Table 7. Variables that best explained the observed density and nesting success of ducks in reservoirs and low-lying basins. Percentage of variation eliminated by the independent variables are in brackets (vegetation = % of island surface covered by forbs and grass-forbs; distance May = distance between island and mainland in May; distance July = distance between island and mainland in July; size = size of island; + = positive influence; - = negative influence).

Dependent variables	Type of waterbody (No. islands)	Independent variables	F value
Density of nesting ducks on islands	Reservoir (N = 25)	- size (54)*** + distance May (8)*	18.05***
	Low-lying basin (N = 35)	+ vegetation (70)*** - size (7)**	54.94***
Nesting success of ducks on islands	Reservoir (N = 25)	+ distance July (30)**	9.80***
	Low-lying basin (N = 24)	+ distance July (29)**	9.05***

*** $P < 0.005$
** $P < 0.01$
* $P < 0.05$

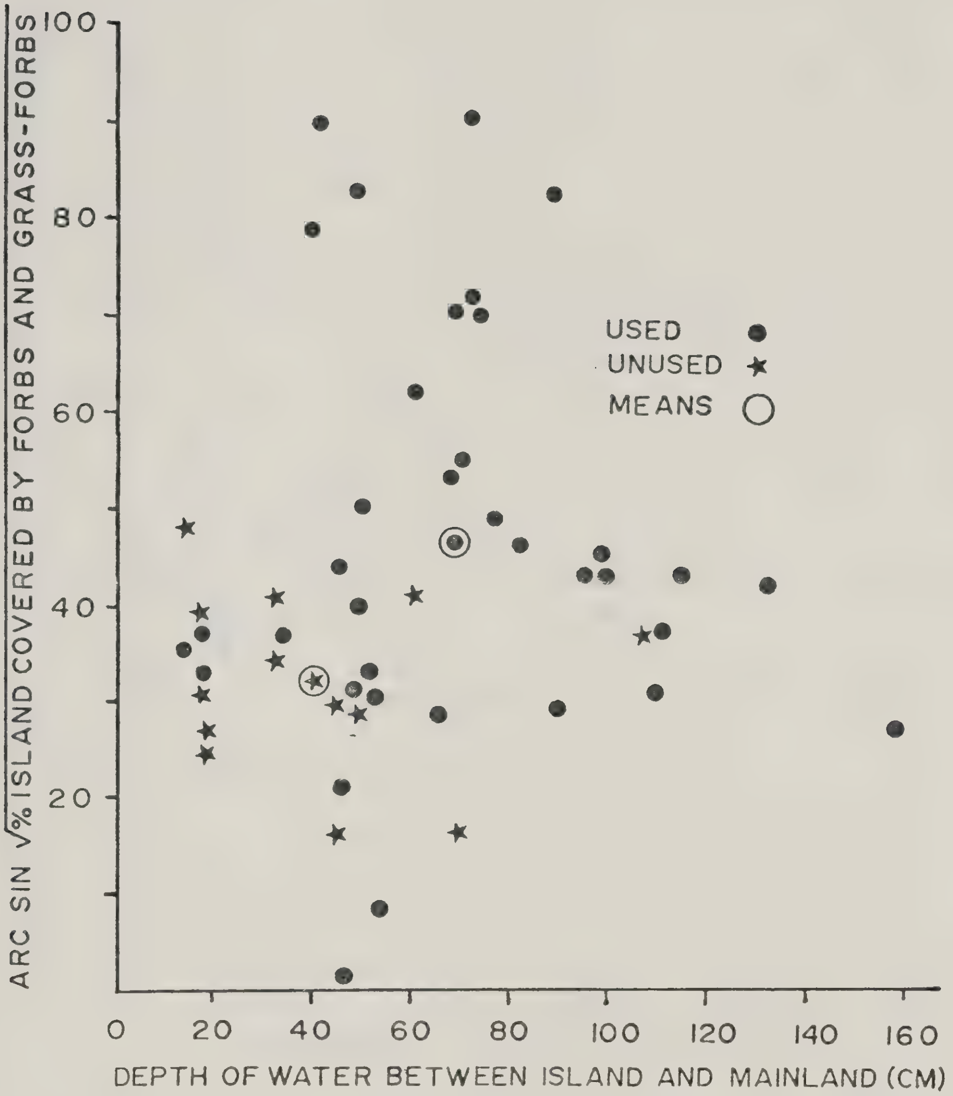

Figure 1. Plot of the most important variables separating islands used and unused by Canada geese as nesting sites in the reservoirs and the low-lying basins as determined by discriminant function analysis (standardized discriminant function coefficient for depth = +0.740 and for vegetation = +0.609; Wilks' lambda = 0.783; df = 2,46; F = 6.37; $P < 0.01$). Vegetation types from Table 2.

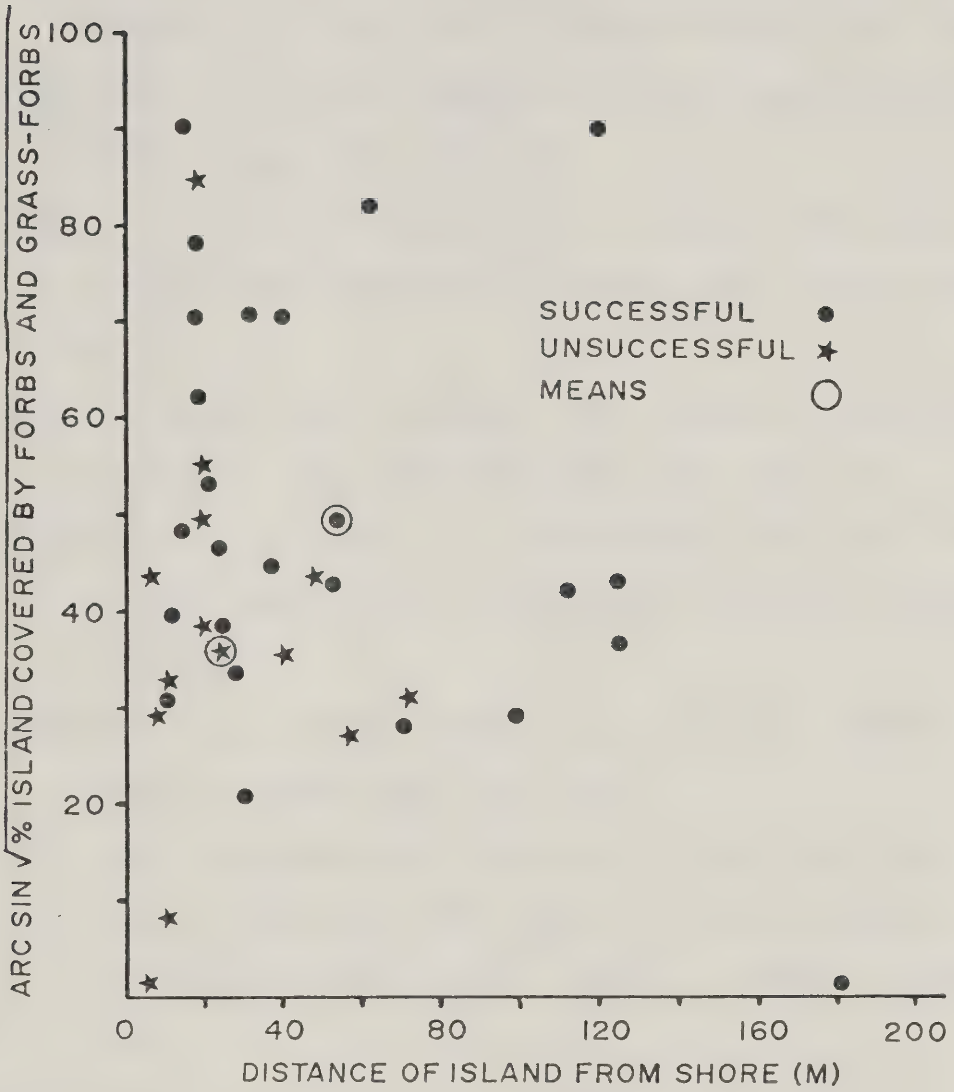

Figure 2. Plot of the most important variables separating islands with at least 1 successful Canada goose nest and those without successful nest in the reservoirs and the low-lying basins as determined by discriminant function analysis (standardized discriminant function coefficient for distance = +0.800 and for vegetation = +0.726; Wilks' lambda = 0.795; df = 2,34; F = 4.38; $\underline{P} < 0.05$). Vegetation types from Table 2.

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PAPER 2. DUCKS NESTING IN ASSOCIATION WITH CANADA GEESE

Abstract

During 2 years, an association involving ducks and Canada geese (*Branta canadensis*) was investigated in southeastern Alberta. Ducks, nesting on islands in association with incubating geese, showed greater densities and greater nesting success than on islands without nesting geese. After the geese left the islands, at hatching, this difference in nesting density and success disappeared. Physical characteristics of islands used and unused by geese were not significantly different. This association between nesting ducks and geese appears to be commensalistic with ducks, particularly mallards (*Anas platyrhynchos*) and pintails (*A. acuta*), receiving benefit from it. Geese are adept at keeping predators away from their nests and indirectly provide protection for ducks that nest in the vicinity. The proximate cause of the association may be a social attraction of ducks to geese.

Introduction

During a study of the use of artificial islands by nesting waterfowl, the distribution of duck nests among the islands was found to be correlated with size, security and vegetative cover of the islands (Giroux 1979). However, this distribution may have been influenced by interactions with other individuals of the same or different species (Hildén 1965). For example, colonially-nesting larids are said to attract nesting ducks (Koskimies 1957, Hildén 1964, Vermeer 1968,1970b) despite this association being considered an ecological trap under some circumstances (Dwernychuk and Boag 1972). Evans (1970) and Alison (1975) presented evidence suggesting a positive association between oldsquaws (*Clangula hyemalis*) and arctic terns (*Sterna paradisaea*) but the relationship is not considered beneficial to the ducks (Alison 1975).

Clustering of nesting ducks, especially mallards, have been reported around Canada geese nesting on islands (Williams 1967, Long 1970). Long (1970) suggested that the association was socially stimulated and selectively advantageous for ducks in that they received protection from geese against potential nest predators. The opportunity to investigate the extent to which ducks were attracted to islands with nesting geese and the possible advantage for ducks arose when Canada geese were found to be nesting on many islands under investigation. I report the results herein.

Study Area and Methods

The study was conducted on a series of islands created by Ducks Unlimited (Canada) in 5 artificial impoundments (A, B, C, D, and E) near the town of Brooks in southeastern Alberta (50.6° N, 111.9° W). Detailed descriptions of the islands and the waterbodies appear in Giroux (1979). I studied islands at impoundment E in 1976 and those at the other impoundments in 1977.

The extent to which ducks were attracted to islands on which Canada geese were nesting was based on a comparison of the numbers of duck nests found on islands with and without nesting geese. On 46 islands searched , 20 (total of 5.8 ha) had at least 1 goose nest (Group I) while 26 (total of 8.4 ha) had no goose nest (Group II). To discern the influence of the physical characteristics of islands and of the presence of nesting geese on the number of duck nests, I compared the 2 groups of islands at 2 periods. For each island, I recorded the total number of duck nests initiated before the last goose left that island (Time 1) and the number initiated thereafter (Time 2). For islands not used by geese, the mean date on which geese left the other islands was used to categorize duck nests initiated during the 2 periods.

To determine if ducks were attracted by the physical presence of an incubating goose, 7 of the 14 rectangular islands at impoundment D, known to be used by nesting geese, were divided in half by erecting 1.25 m high solid panels

across their width. These islands were subsequently searched for nests as were the other islands.

The physical characteristics of the islands were compared using a multivariate analysis of variance (Cooley and Lohnes 1971). Differences in nesting density and success were tested using t-tests and chi-square contingency tests (Sokal and Rohlf 1969). Species composition of ducks on the 2 groups of islands was compared with a test of independence using the G-statistic. The level of significance was established at 5%.

Results

In both years, the mean date on which geese left the islands varied in the different basins (May 19 to 29). Duck nests were initiated over a period of 5 weeks while geese were still associated with the islands and another 10 weeks after the nesting geese had left the islands. During the 1st period, more ducks ($\underline{P}<0.01$) initiated nests on islands with nesting geese than on islands without geese (Table 1). After the geese left the islands, the number of ducks initiating nests on the same group of islands was still greater, but not significantly so, than on islands unused by geese. This suggests that the presence of nesting geese made these islands more attractive to nesting ducks than islands without nesting geese.

Physical characteristics of Group I islands (Table 2) tend to make them more attractive to nesting ducks than islands of Group II (Giroux 1979). However, because variation in these characteristics was great, a multivariate analysis of variance showed that islands used by nesting geese did not differ significantly from unused islands (Table 2). If we consider that a factor of 1.3 was a residual differential value between the 2 sets of islands (Table 1) attributed to their physical characteristics, then the additional difference of 1.9 between Time 1 and Time 2 can be attributed to the presence of geese nesting on the islands. This comparison assumes that there was no change in the relative attractiveness of the 2 groups of islands

during the 2 periods. Size and island perimeter remained constant over the season. Vegetative cover increased with the advance of the season but I have assumed that the increase was relatively the same on all islands, albeit total coverage varied among islands. Depth and distance from shore declined with advancing season, making some islands more vulnerable than others to nest predators. This loss of security and hence loss of attractiveness, was more pronounced for islands in Group II than in Group I (Table 2). Therefore, if densities of duck nests were affected only by the physical characteristics of islands, we should find a greater decline of density at Time 2 for islands of Group II than for those of Group I, but we did not. This suggests that departure of the nesting geese from islands of Group I reduced their attractiveness during Time 2.

On 5 islands that were divided by an artificial barrier and used by nesting geese, the numbers of ducks nesting on the side occupied by the geese and the opposite side were recorded (Table 3). When the geese were associated with the islands, more ducks initiated nests on the half occupied by geese than on the other half, a trend that was reversed when the geese had left the islands. These observations support the previous observations suggesting that nesting ducks are attracted to nesting geese. However, differences were not significant possibly because of small sample size.

A nest was considered successful if at least 1 egg in

the clutch hatched. Mammalian predation was the main cause of nest losses on the islands studied (Giroux 1979). Skunks (*Mephitis mephitis*), badgers (*Taxidea taxus*) and coyotes (*Canis latrans*) were seen on islands and many nests lost to predators showed signs of these mammals. While nesting geese occupied islands, nesting ducks associated with them were more successful ($P<0.005$) than ducks nesting on islands without geese (Table 4). After the geese had left the islands, nesting success of ducks on the 2 groups of islands was not significantly different. This suggests that presence of nesting geese made islands safer for nesting ducks. Success of ducks nesting on islands in Group II, for which there was a relatively greater reduction in security because of a drop in water levels, and hence greater vulnerability to mammalian predators, did not change significantly between the 2 periods (Table 4). This contrasts with the situation on islands in Group I where nesting success decreased ($P<0.005$) during the 2nd period, yet the decline in security was less marked. This suggests that some factor other than water level influenced security of the islands, the most obvious being the presence of nesting geese. Thus, attraction of ducks to islands where geese were nesting may be related ultimately to the security of the islands for ducks and their hatching success.

Canada geese were the 1st birds to initiate nests on these islands. Among ducks, mallard and pintail are the earliest to nest (Sowls 1955:83). Thus it is not surprising

to find that 64% of 112 ducks that began nesting when the geese were laying or incubating were mallards and pintails. The species composition of nesting ducks on islands used and unused by geese was similar (Table 5), suggesting that all species are attracted equally to nesting Canada geese.

By the time geese left the islands, only 4 of 82 clutches of ducks established on islands with nesting geese had hatched. Fifty-six of the remaining 78 ducks had completed their clutches and begun to incubate at that time; the remainder were in various stages of completion. Therefore, it appears that most ducks were in the process of laying or incubating by the time geese left the islands.

Discussion

My observations support the suggestion of Long (1970) that nesting ducks are attracted to the vicinity of nesting Canada geese. Moreover, data on nesting success suggest that the association benefits ducks significantly. Since the geese apparently are not affected by the presence of nesting ducks, the relationship can be considered commensalistic. The benefit to the ducks seems to reflect the ability of geese to drive off potential nest predators. Hammond and Mann (1956:348) claimed that a pair of Canada geese can successfully defend their nest against crows (Corvus brachyrhynchos) and smaller mammals. Uhler (1956:464) reported that Canada geese nesting on islands are apparently able to defend their nests against raccoons (Procyon lotor). Ewaschuk (1970:45) recorded geese chasing crows from the vicinity of their nests on 23 occasions. In 1977, I observed a pair of geese in the water near the island they defended respond to a crow that flew over the island by flying onto the island and calling. A similar response was made to gulls that were flying in the vicinity of an island occupied by another pair of geese which, at the time, were feeding at about 60 m from the island. I also recorded a few instances in which groups from 2 to 18 geese successfully chased a skunk from the vicinity of nesting islands during their incubation period. A comparable incident was observed by W. M. Glasgow (pers. comm.) when he saw a badger retreating to a den when threatened and chased by a gander. However,

geese are unable to protect their nests from coyotes (Vermeer 1970a:240). These observations suggest that Canada geese can keep some of the smaller nest predators away from their nests and, in so doing, provide protection to ducks that nest in their vicinity.

Such protection by geese can only be effective while they remain associated with the nesting islands. By the time geese left the islands, most ducks were completing their clutches or incubating. Thus, protection offered by geese to nesting ducks must be through both laying and incubation periods of the ducks. When nests are unattended during the laying period, they are reported to be more susceptible to predation than when females are incubating (Choate 1967, Bengtson 1972).

Williams (1967:122) considered the ability of ducks to nest near incubating geese evidence of tolerance by the geese. Ewaschuk (1970:49) observed no interactions between ducks and incubating Canada geese; he noted that ducks were tolerated on the territory of geese and in some cases were seen to walk in the vicinity of an incubating female with no apparent response from either goose or gander. On the other hand, Cooper (1978:30) noted that incubating geese challenged all ducks that approached the nest. During the pre-incubation period of geese, I observed many instances in which geese, while preparing their nest sites or laying, showed no response to nearby ducks. However, I did observe 2 pairs of geese that demonstrated aggressiveness towards

ducks. One pair chased mallards and pintails from the vicinity of their nest on 9 instances. No duck nested on that particular island when the geese were present. A 2nd pair was observed in 2 short interactions with 3 ducks. These observations may reflect individual variation in the level of tolerance. Nevertheless I suggest that, in southeastern Alberta, the majority of geese permit ducks to nest in close association with them.

An interesting aspect of this association concerns its proximate cause. Hildén (1965) suggested that the innate releasing mechanism involved in nest site selection can be reinforced by learning. This hypothesis has been postulated to explain why ducks nest in association with gulls and terns (Koskimies 1957, Vermeer 1968). It is suggested that the habit may be transmitted to later generations by imprinting of the ducklings onto the larid colonies through acoustic or optic cues. However, in the association with geese, few ducklings had hatched when geese left the islands, thus eliminating the possibility for imprinting the ducklings cn the geese.

Initial establishment of ducks on islands used by geese could have occured by chance. This possibility has been considered by Evans (1970) for the association between oldsquaws and arctic terns. Nest site fidelity in subsequent years is more probable among ducks that hatch their clutches successfully than among those that have their clutches destroyed (Hildén 1965, Doty and Lee 1974). Then

differential nesting success among ducks using islands with and without nesting geese (Table 4) may contribute to the accretion of nesting ducks on islands used by geese. However, Canada geese do not use the same islands every year which may result in some homing ducks nesting on islands without geese. During the entire study (Giroux 1979), 81% of 43 islands were used on 2 successive years by nesting geese. Nevertheless, I calculated that if the association was by chance alone, the difference observed in nesting density would require a minimum of 6 years based on 2 assumptions: that all the surviving females that nested successfully on an island would return to that same island and that the number of new females that nest on an island in a given year would be similar to the number of the previous year. Since the association in this study has evolved over an average of only 3.5 years, it is unlikely that it has arisen by chance alone.

Alison (1975) has suggested that the proximate factor favoring the association between oldsquaws and arctic terns was probably the selection of the same type of habitat. However, data from this study do not support this hypothesis because if there were selection of the same type of islands by ducks and geese, we should find the same difference in densities between the 2 groups of islands or in other words similar ratios at both periods, but we did not (Table 1). On the other hand, there is perhaps selection of different types of islands by the various species of ducks which nest

at different times over the summer. For instance, mallard and pintail nest predominantly in Time 1 and may select Group I islands while lesser scaup (*Aythya affinis*) and gadwall (*Anas strepera*) nest later (Time 2) and may select Group II islands which could explain the decrease of ratio at Time 2. However, when only data for early nesters (mallard and pintail) are analysed, a similar decrease of ratios is found (from 2.9 to 1.2) to that when all species of ducks are pooled together (Table 1). Thus it is improbable that the association between ducks and geese originated from selection of the same type of island.

It is more likely that the association has arisen from an active attraction of ducks by geese. This social stimulus has been suggested by Long (1970). Large size and conspicuous territorial behavior of geese probably make them obvious to ducks. Sight of a large goose building her nest or incubating may also constitute a stimulus to other waterfowl selecting nest sites. The only data that I have to support this hypothesis were collected at impoundment D where artificial barriers divided some islands in half. On these islands, more ducks established their nests on the same side as the incubating goose. Perhaps the numbers of nesting ducks on the 2 halves of these islands were not more different because the presence of a pair of geese on a particular island may be sufficient to attract ducks to the island since geese usually defended its entirety (Giroux 1979).

In summary, I suggest that ducks are socially attracted to islands where nesting geese are present; this has a survival value especially for early nesting ducks (mallards and pintails) which receive protection from predators through the presence of geese nesting on the islands. Such association between ducks and geese may have management implications. The property of geese to attract and protect nesting ducks should be exploited by providing nesting structures that can support at least 1 goose and several duck nests. Therefore, the creation of earthen islands like those considered in this study should be preferred over artificial structures such as washtubs, elevated and floating platforms or round hay bales which usually support only 1 goose nest (Brakhage 1966, Rienecker 1971).

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Table 1. Number of nests initiated by ducks during and after occupation of a series of islands by nesting Canada geese near Brooks, Alberta.

Islands	Mean No. of nests per ha per week ± SE	
	Time 1[a]	Time 2[b]
Used by geese	4.1 ± 0.76	2.6 ± 0.44
Unused by geese	1.3 ± 0.23	2.0 ± 0.34
Ratio	3.2:1	1.3:1

[a] Period when geese were associated with islands (April to mid-May).

[b] Period after geese had left the islands (mid-May to August).

Table 2. Characteristics of artificial islands used and unused by Canada geese for nesting near Brooks, Alberta.

Characteristics	Mean ± SD	
	Used by geese	Unused by geese
Size of islands (ha)	0.69 ± 1.44	0.76 ± 1.22
Perimeter of islands (m)	331.9 ± 259.9	337.7 ± 237.7
Vegetative cover [a] (%)	44.8 ± 15.0	24.0 ± 8.8
Distance[b],Time 1[c] (m)	57.5 ± 47.5	49.9 ± 82.0
Distance,Time 2[d] (m)	24.6 ± 33.9	3.2 ± 5.3
Depth[e],Time 1 (cm)	70.0 ± 42.8	46.4 ± 36.2
Depth,Time 2 (cm)	35.7 ± 34.2	13.9 ± 22.3

Wilks' lambda = 0.732; df = 7,38; F = 1.99; $P > 0.05$.

[a] Percent of island surface covered by forbs and grass-forbs measured in July (Giroux 1979).

[b] Distance between island and mainland.

[c] Period when geese were associated with islands (April to mid-May).

[d] Period after geese had left the islands (mid-May to August).

[e] Depth of water between island and mainland.

Table 3. Number of nests initiated by ducks during and after the occupation by nesting Canada geese of 5 islands divided in half with artificial barriers.

Half	No. of nests per week	
	Time 1[a]	Time 2[b]
With goose nest	1.2	0.9
Without goose nests	0.8	1.1
Ratio	1.5:1	0.8:1

[a] Period when geese were associated with islands (April to mid-May).

[b] Period after geese had left the islands (mid-May to August).

Table 4. Nesting success of ducks (%) during and after occupation of some islands by nesting Canada geese.

Islands	Time 1[a]	Time 2[b]
Used by geese	56 (102)[c]	27 (162)
Unused by geese	28 (47)	23 (171)

[a] Period when geese were associated with islands (April to mid-May).

[b] Period after geese had left the islands (mid-May to August).

[c] Figures in parentheses are the total number of nests.

Table 5. Species composition of ducks nesting in association with Canada geese on artificial islands in impoundments near Brooks, Alberta, during Time 1[a].

Species	Number of nests	
	Used by geese	Unused by geese
Mallard	44 (39)[b]	16 (34)
Pintail	28 (25)	16 (34)
Other[c]	40 (36)	15 (32)
Total	112 (100)	47 (100)

[a] Period when geese were associated with islands (April to mid-May).

[b] Figures in parentheses are percentages.

[c] Includes blue-winged teal (*Anas discors*), northern shoveler (*A. clypeata*), American wigeon (*A. americana*), gadwall, lesser scaup and redhead (*Aythya americana*).

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PAPER 3. EFFECT OF DROUGHT ON WATERFOWL USE OF ARTIFICIAL IMPOUNDMENTS ON THE PRAIRIES OF ALBERTA

Abstract

The effect of variation in precipitation on the use that nesting ducks made of islands in artificial impoundments in southeastern Alberta was evaluated over a 3-year period. During 1 year when drought conditions prevailed, more ducks nested on islands than during the 2 years when normal conditions prevailed. Gadwall (*Anas strepera*) showed the greatest relative and absolute increase in the number of nests under the dry conditions. Implications of these changes in numbers of nesting ducks are discussed from the standpoint of local distribution and overall production.

Introduction

Annual precipitation characteristically fluctuates on the plains of North America and these fluctuations dictate the number of temporary ponds present each year (Pospahala *et al* 1974). When dry conditions prevail the number of potholes declines, part of the breeding population from the plains is reportedly displaced to the North (Smith 1970, Pospahala *et al* 1974) and production of ducks declines over the continent as a whole (Crissey 1969, Smith 1970). One reason postulated for lowered production under drought conditions is that the reproductive potential of ducks moving to higher latitudes is lower (Smith 1970, Calverley and Boag 1977). The latter authors suggest that management of waterfowl breeding habitat on the plains should strive to minimize this northward displacement of birds, particularly mallards (*Anas platyrhynchos*) and pintails (*A. acuta*), by providing waterbodies that would persist through dry years. While studying the use of man-made islands by nesting waterfowl in southeastern Alberta (Giroux 1979), I had the opportunity to document the effect of drought on the use of artificial impoundments by nesting ducks.

Study Area

This study involved 3 impoundments created by Ducks Unlimited (Canada) near Brooks (50.6° N, 111.9° W), Alberta, in an area of mixed prairie (Coupland 1950). One was an irrigation reservoir (B) with 13 km^2 of flooded area and a maximum depth of about 5 m. The others were shallow basins (D and E) with areas of 2.3 and 1.4 km^2 and a maximum depth of about 1 m. A series of islands were artificially-created in these impoundments by either cutting off peninsulas (reservoir) or by piling up earth scooped out from a surrounding moat (shallow basins). Detailed descriptions of the islands appear in Giroux (1979). Throughout the summer, irrigation and evapo-transpiration contributed to the decline of water levels in the impoundments which were refilled in fall and early spring with water from the Bow River.

Methods

Impact of drought on waterfowl use of these artificial waterbodies was based on the relative number and success of ducks nesting on the islands created in them. From 1976 to 1978, an area of about 8.4 ha of island habitat was systematically searched for nests (Giroux 1979). The same islands (34) were studied each year. In 1976 and 1978, 2 searches were done by walking 1 series of transects parallel to the long axis of each island. In 1977, 4 searches were conducted each consisting of 2 series of transects perpendicular to each other. To allow comparisons among the 3 years, I eliminated the 42 nests (13%) found during the 1st and 4th search in 1977 which were before and after those conducted in 1976 and 1978. I also eliminated the 23 nests (7%) missed during the 1st series of transects but located during the 2nd.

All nests containing 1 or more eggs were recorded by plotting them on maps of the islands. If eggs were absent, probably the result of predation, nests were recorded only if fresh down and nest material were still present in the nest bowl. Species of waterfowl that initiated nests were identified by either flushing the female or using characteristics of nest and associated eggs, down or contour feathers. A nest was considered successful if at least 1 egg in the clutch hatched.

Precipitation data were collected at the Brooks weather station, 25 km northwest of the study area. In each basin,

water levels were noted regularly using permanent guages installed by Ducks Unlimited (Canada).

Comparisons of data included an approximate test of equality of means with heterogeneous variances and a test for independence using the G-statistic (Sokal and Rohlf 1969); the level of significance was established at 5%.

Results

Habitat conditions

Precipitation falling between September and April influences spring run-off and consequently habitat conditions for waterfowl in spring. Precipitation during this period was 27% higher in 1975-76 and 45% higher in 1977-78 than the 30-year average (154.1 mm). By contrast, during the same period of 1976-77, precipitation fell to 42% below that of the long-term average. These differences were reflected in water conditions recorded during breeding pair surveys conducted in May on the prairies (Table 1). In 1977, the mean number of ponds per transect was lower ($P<0.005$) than in 1976, 1978, and the 13-year average for all types of ponds except the category "other" (Table 1). Thus conditions in 1977 can be considered well below average for waterfowl whereas 1976 and 1978 can be considered about average.

At reservoir B, water levels were similar in early June 1976 and 1977 but slightly lower in 1978 (Table 2). In the low-lying basins (D and E), dry conditions of 1977 were more marked, especially at E where conditions in 1978 still reflected the low availability of water in 1977 (Table 2).

Numbers of nesting waterfowl

In 1977, the number of duck nests found on the islands searched increased, resulting in a density increase of 72% over that in 1976 (Table 3). The following year the number of nests decreased and density declined to only 23% above

that of 1976. Nesting success showed a slight decrease during the last 2 years (Table 3). Mammalian predators including skunks (*Mephitis mephitis*), badgers (*Taxidea taxus*) and coyotes (*Canis latrans*) were the main cause of nest losses on the islands (Giroux 1979). During the summers of 1976 to 1978, they accounted for 76, 90, and 54% of the known nesting failures. Relative to 1976, the number of successful nests per ha rose by 56% in 1977 but was only 15% higher in 1978.

The species composition nesting on the islands changed ($P<0.005$) between years (Table 4). The relative proportions of mallard, pintail, and gadwall were about the same in 1976 and 1978 but in 1977 the proportions of the former 2 decreased while that of gadwalls increased. A similar change was recorded for gadwalls in the surrounding area where it represented 7, 15, and 6% of the breeding pairs counted between 1976 and 1978 (Ducks Unlimited [Canada], unpubl. data).

Discussion

The prairie pothole region of North America produces more waterfowl than any other ecological zone but this productivity is very sensitive to variation in weather conditions (Pospahala _et al_ 1974). The number of potholes available in spring on the prairies determines the number of pairs that remain to breed (Drewien and Springer 1969). Absence of spring run-off and limited precipitation in southeastern Alberta in 1977, resulted in a considerable decline in number of waterbodies on the prairies (Table 1). I assume that a reduction in water levels also occured in the remaining waterbodies (Drewien and Springer 1969). Under these dry conditions, the number of nests initiated on man-made islands located in artificial impoundments increased by 102% over 1976. Despite lower water levels, these impoundments still held more water than adjacent prairie wetlands.

The total number of nests includes an undetermined number of renesting attempts and therefore does not represent the absolute number of breeding females. However, since the proportion of females renesting is reported to be lower during periods of drought (Salyer 1962, Stoudt 1969), the increase in numbers recorded nesting in 1977 should represent relatively more nesting females than in either 1976 or 1978.

The increase in 1977 was greater than could be explained by homing of all surviving females that nested on

these islands in 1976 plus all of those females that were produced on them in 1976 (Table 5). Moreover, a homing rate of 50% is more realistic (Doty and Lee 1974) and therefore the increase must have represented immigration.

Greater attractiveness of the islands through modification of their physical characteristics is also unlikely to explain this increase of nesting ducks since their number decreased in 1978 on the same group of islands. The only major change in 1977 was the loss of prairie wetlands nearby. Thus the persistence of water in adjacent artificial impoundments would seem to have caused waterfowl to immigrate into them to nest. Similar conclusions have been reached by Smith (1969), Dzubin (1969) and Sugden (1978) who suggested that displacement of ducks from deteriorating habitat contributes to an increase of birds in other areas where water persists.

Nesting success was slightly lower during the last 2 years of the study (Table 3). High densities of nests recorded in 1977 were not considered to affect the nesting success of ducks (Giroux 1979). However, lower water levels in some impoundments reduced the security of islands in them; maximum predation was recorded with minimum water levels. In other studies, decrease of hatching success during drought also has been attributed to increased predation and mortality of embryos (Salyer 1962, Rogers 1964, Stoudt 1969).

Despite a lower nesting success in 1977, the actual

number of successful nests increased by 85% during the dry conditions of 1977. Although nesting success is only 1 step in production, it suggests that the overall impact of drought on waterfowl in an area with artificial impoundments may be less detrimental than in areas without them. Drought usually has been reported to have adverse effects on waterfowl production in local studies (Salyer 1962, Rogers 1964, Stoudt 1969), in regional surveys (Stewart and Kantrud 1974, Brewster et al 1976), and on a continental basis (Crissey 1969, Smith 1970). During the drought of 1977, the presence of artificial impoundments in southeastern Alberta provided suitable nesting habitat for homing waterfowl and apparently attracted other birds displaced from more deteriorated areas. To what extent these basins with artificially manipulated water levels attract ducks that would otherwise overfly the area in times of drought remains unknown. Except for the incidental observations reported by Hansen and McKnight (1964), there is no good evidence that displaced ducks actually nest in the arctic (Nudds 1978). Moreover, even if they do , the reproductive potential of ducks nesting in the arctic (homing and perhaps displaced) is lower than in the parkland (Calverley and Boag 1977).

No data on fledging success are available from this study, but reservoir B, with its permanent water supply, appeared to provide adequate brood habitat even during the drought period. However, the situation became more critical in the shallow basins (D and E) when declining water levels

decreased the quality of the habitat. It even may have constituted a threat to survival of the broods. These impoundments with artificial islands were attractive to breeding pairs in spring but may have become a "trap" during the brood rearing period if birds were forced to search for more permanent waterbodies and thus exposed themselves to predators (Dzubin and Gollop 1972).

Relative proportions of mallards and pintails in the island-nesting population fluctuated over the 3 years with a decline in 1977 that may have represented a northward displacement of these species (Smith 1970, Pospahala et al 1974). By contrast, gadwalls were more abundant during the drought of 1977 showing an increase in relative abundance and in absolute number of nests (346%). In Utah, Weller et al (1958) noted an increase of 45% in the number of gadwall nests during a drought while Brewster et al (1976) recorded an increase in the relative proportion of the breeding population during a dry year in South Dakota. Crissey (1969:170) stated that the cause of an apparent increase in gadwall numbers during droughts has yet to be determined. The relative increase may be explained by looking at the habitat used during the breeding period. Gadwall appear to be associated with larger and deeper marshes (Duebbert 1966, Long 1970, Hines 1975) which are more likely to persist even during dry periods. By nesting later, gadwalls are also less likely to select waterbodies that will dry up and become traps. Finally, they are probably less affected by drought

than most other species in terms of nesting cover since they usually select dry upland nest sites (Duebbert 1966, Long 1970, Hines 1975).

Management Implications

Little information on the effect of drought on waterfowl using artificial impoundments has been published. On islands located in artificial waterbodies in southeastern Alberta, a greater density of successful nests was recorded during a dry year than during years with normal conditions. Creation of artificial impoundments could be promoted on the prairies to minimize the impact of dry conditions on waterfowl production. However, it is imperative that the new habitat be suitable for waterfowl until the young are fledged. If not, such impoundments may be an ecological trap benefiting mainly the predators of waterfowl and if so should not be constructed.

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Table 1. Mean number of ponds per transect located on the prairies of Alberta, comparing 1976, 1977, 1978 and the 1966-78 average (Ducks Unlimited [Canada], unpubl. data)[a].

Type of ponds	Mean ± SD			
	Average	1976	1977	1978
A (< 0.2 ha)	6.0 ± 5.7	6.7 ± 6.1	1.3 ± 1.9	7.7 ± 7.2
B (0.2 - 0.4 ha)	1.4 ± 1.8	1.4 ± 1.6	0.5 ± 1.5	0.7 ± 1.0
C (> 0.4 ha)	1.5 ± 1.7	1.2 ± 1.8	0.3 ± 0.7	0.9 ± 1.0
Other[b]	2.7 ± 3.8	3.7 ± 3.3	2.2 ± 2.2	3.9 ± 3.1
Total	11.7 ± 9.4	13.0 ± 9.2	4.3 ± 4.7	13.2 ± 10.0
% deviation from average		+ 11	- 63	+ 13

[a] Censuses were conducted in May along 26 roadside transects each covering 2.6 km^2.

[b] Includes stream, dugout, borrow-pit, irrigation ditch and stockdam.

Table 2. Difference in water elevation in early June 1977 and 1978 compared to 1976 in 3 artificial impoundments near Brooks, Alberta.

Impoundment	Difference from 1976 (mm)	
	1977	1978
B	-3	-24
D	-91	-15
E	-143	-46

Table 3. Number and success of ducks nesting on islands in 3 artificial impoundments near Brooks, Alberta, 1976-78.

	1976	1977	1978
Number of nests	125	253	167
Density of nests (No/ha)	17.2	29.6	21.2
Success (%)	54	50	51
Density of successful nests (No./ha)	9.4	14.7	10.8

Table 4. Species composition of ducks nesting on islands in 3 artificial impoundments near Brooks, Alberta, 1976-78.

Species	Number of nests		
	1976	1977	1978
Mallard	27 (24)[a]	46 (19)	38 (24)
Pintail	27 (24)	28 (11)	30 (19)
Lesser scaup	19 (17)	60 (24)	40 (25)
Gadwall	13 (11)	58 (24)	16 (10)
Teal[b]	12 (10)	30 (12)	9 (5)
Other[c]	17 (14)	25 (10)	28 (17)
Total	115 (100)	247 (100)	161 (100)

[a] Figures in parentheses are percentages.

[b] All 3 species of teal were grouped together.

[c] Includes American wigeon, redhead, northern shoveler, ruddy duck and white-winged scoter.

Table 5. Number of females observed and expected to nest on islands in artificial impoundments near Brooks, Alberta, 1976-78.

Year	No. expected[a]	No. observed[b]
1976	-	91
1977	130	189
1978	267	123

[a] The number of expected females was based on the homing of all the surviving females that nested or were produced on the islands. A survival rate of 54 and 46% were considered respectively for adults and juveniles (Anderson 1975) with an average of 5.7 fledged birds per successful nests (Pospahala _et al_ 1974) and an equal sex-ratio.

[b] The number of observed females was based on the number of nests (Table 4) with a renesting rate of 69% (Keith 1961:Table 57). It was assumed that the nesting success of the first attempts was similar to the success of all the nests.

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CONCLUDING DISCUSSION

Recently, Bellrose and Low (1978) stated that acquisition and development of wetland habitat is an important aspect in waterfowl management but that such activities are in conflict with agriculture. Therefore they stressed the importance of producing more waterfowl per unit area and they suggested that techniques such as nesting islands should be improved and used more extensively. I investigated the use of artificial islands on the prairies of Alberta and concluded that this technique is effective in producing a good number of ducklings and goslings at nest exodus in a limited area. Aggregation of nests on insular habitat may be achieved by homing of adult and young females that suffer reduced mammalian predation when nesting on these islands (Hildén 1965, McKinney 1965).

Results of this study supported the hypothesis of Hildén (1965) regarding the mechanisms involved in habitat selection by birds. Use of islands by nesting waterfowl was influenced by the physical characteristics of the environment and by interactions among birds of the same and different species (Fig.1). In general, the artificial islands were considered attractive to waterfowl but nesting success was sometimes low. Since the objective of the technique is to augment waterfowl production, the physical characteristics of islands appear to be the easiest to manipulate to increase productivity on them.

Improvement can be achieved by locating islands farther from shore; a distance of 170 m and a depth of 75 cm between the islands and the shore should limit access of mammalian predators to the islands, making them more attractive and safer for both nesting ducks and Canada geese. Also, a distance of at least 100 m between islands should decrease mammalian predation. Size and establishment of nesting cover are 2 other characteristics to consider when building islands. Minimal size for optimal production has yet to be determined but, from this study, an island of 0.1 ha appears to be the most productive. Establishment of vegetation on islands can be accelerated by seeding; type and quantity of seeds to use depends upon soil and moisture conditions particular to each area. With the dry conditions prevailing on the prairies, it would be appropriate to water the islands at the time of seeding.

Other factors influencing production on islands are the interactions between birds (Fig. 1). Intraspecific interactions among ducks on nesting grounds are not obvious but their effect may be viewed indirectly through distribution of nests. Newton and Campbell (1975) found that in homogeneous habitat, nests of a same species were spaced regularly. This spacing is apparently achieved by females when selecting their nest sites (Duebbert 1966, Newton and Campbell 1975).

In this study, mallard, gadwall, and lesser scaup nested at a greater density and selected islands to a

greater extent than the other species of ducks found in the area. What permitted such dense nesting in these 3 species is unknown. McKinney (1965) suggested that modification of behavior may enable species such as mallard and gadwall to nest at high density in insular habitat. In such instances, islands are used for nesting only and are not considered part of the territory (Hammond and Mann 1956, Weller 1964, Newton and Campbell 1975). McKinney (1965) considered that mobility of the pair was important so that not all activities need to be accomplished on the islands. Concentrations of nests in Aythya species probably reflect a low level of aggressiveness in this genus relative to Anas (McKinney 1965). For the other species, such as pintail, blue-winged teal, northern shoveler, and American wigeon that showed less affinity to islands, it was not possible to determine whether they were avoiding islands per se or if they were intolerant of or subordinate to other individuals already established on the islands. McKinney (1965) suggested that northern shoveler tend to space out their nests through hostility between pairs.

Interspecific hostility is rare among different species of ducks nesting in a same area (McKinney 1965). Bengtson (1970) observed no evidence of interspecific aggression between females while Newton and Campbell (1975) found that each species tolerated other species closer than its own. Long (1970) observed that nesting ducks were apparently more alarmed by the presence of an experimental dummy of their

own species near their nests than that of a different species. Variation in nesting chronology of the different species may also decrease interspecific competition. Of the 3 common nesters on the islands, mallards, which nest early in the season, appear to be isolated in time from lesser scaup and gadwall that nest later (Keith 1961). This temporal spacing, the low degree of interspecific territoriality, and selection of different types of nesting cover (Long 1970) all contribute to keep interspecific competition to a minimum and allow maximum use of islands.

Defense of an entire island by a single pair of Canada geese and interactions among the birds usually prevented establishment of more than one pair per island, especially on the small islands in the low-lying basins. However, initiation of 2 nests per island may be promoted by the establishment of tall forbs over the entire island which appear to decrease the visual stimuli and hence interactions between pairs. Ewaschuk (1970) observed a shorter nearest-neighbor distance (11 m) between nests located in shrubs than between those found in short grass (26 m). He also found an inverse relationship between the number of interactions between pairs and vegetation density which may act as a visual barrier. Although nesting success was lower on islands with 2 or more nests, the net production at nest exodus per island was greater on those islands than on islands with a single nest.

Establishment of more than 1 goose nest per island may

also extend the period that geese are associated with the islands. Presence of nesting geese on islands attracted ducks to nest there at the same time protecting them against potential nest predators (Fig. 1). This interspecific association which benefited the ducks significantly is considered commensalistic.

Finally, environmental conditions such as the availability of natural prairie wetlands are also important in influencing production on islands (Fig. 1). Annual variation in precipitation on the prairies dictates the number of temporary ponds which have a direct influence on waterfowl production (Crissey 1969, Smith 1970). A decrease in the number and quality of these ponds during a dry year, increased waterfowl populations on the artificial impoundments investigated in this study.

During periods of drought on the prairies, ducks have several possibilities. A number of birds home to the prairies and fill the suitable habitat which becomes rapidly limited. Other individuals are displaced to more permanent waterbodies (Smith 1969, Dzubin 1969, Sugden 1978, this study) and some others may not nest at all (Rogers 1964, Smith 1969, Dzubin and Gollop 1972). There is also some indication that a part of the population is displaced to the northern breeding areas (Smith 1970, Pospahala _et al_ 1974). Based on observations of unmarked birds, Hansen and McKnight (1964) claimed that drought-displaced ducks have nested successfully in the arctic. Except for these incidental

observations, there is no evidence that ducks nest in the North after having extended their migration beyond the prairie latitudes (Nudds 1978). Even if they do so, Calverley and Boag (1977) found that birds breeding in the arctic nested with lower reproductive potential than those nesting in the parkland. Therefore, presence of artificial impoundments may prevent some birds from overflying the prairies and allow them to reproduce with greater potential than at more northern latitudes.

Since artificial impoundments are attractive to breeding pairs in spring, it is imperative that they remain adequate until the young are fledged otherwise they would become "ecological traps" and therefore should not be constructed.

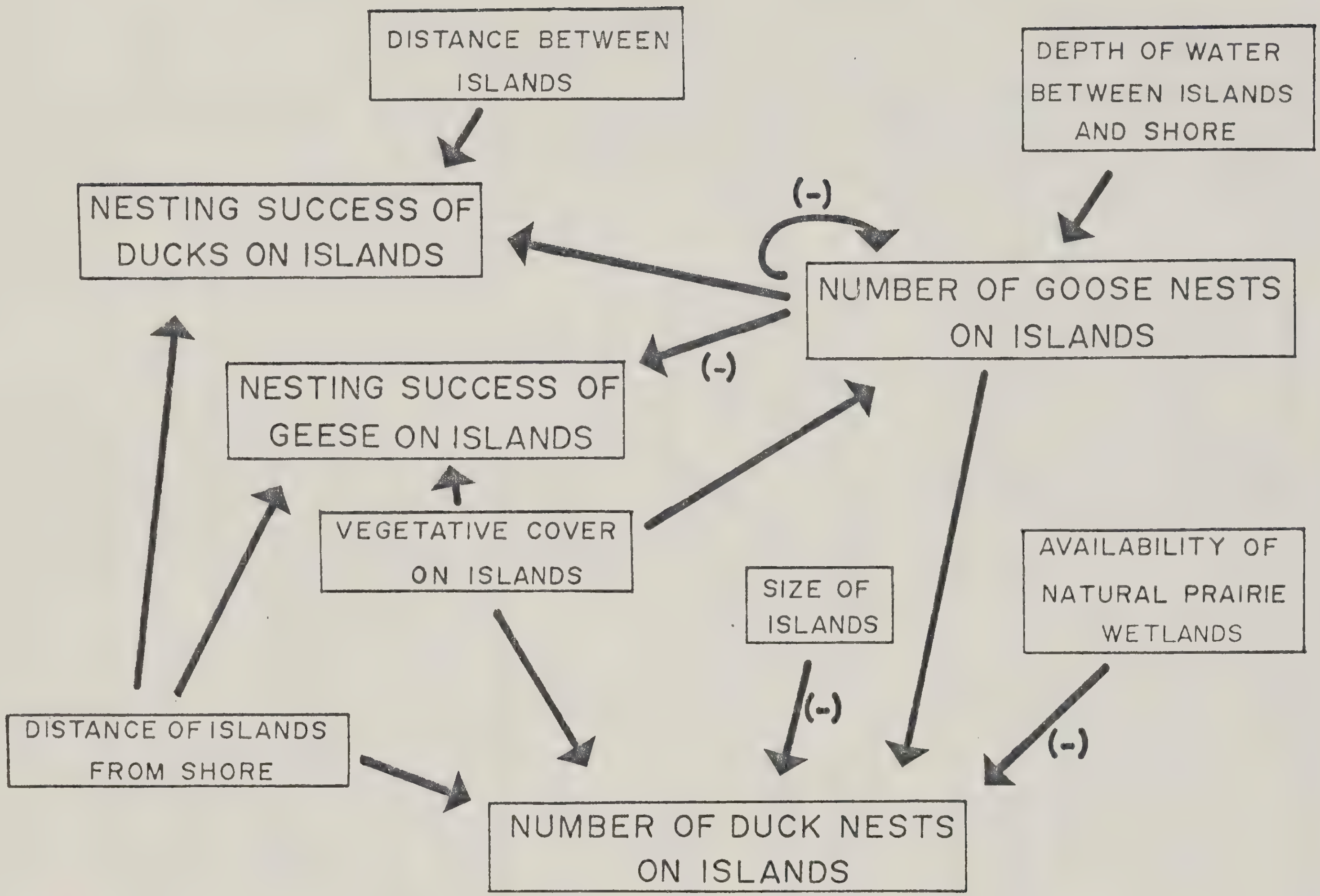

Figure 1. Factors influencing the number and success of ducks and Canada geese nesting on artificial islands on the prairies of Alberta (-:negative effect or inverse relationship).

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